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Ichikawa et al.

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(54) **POWER SUPPLY DEVICE AND VEHICLE INCLUDING THE SAME**

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H02J 7/14 (2006.01)

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(58) **Field of Classification Search** 320/10.1, 320/104; 307/10.1

See application file for complete search history.

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(57) **ABSTRACT**

A power supply device includes a power storage unit capable of being charged and a control unit controlling charging of the power storage unit. Control unit includes a battery ECU for setting, at the start of charging of the power storage unit, a target value of state of charge of the power storage unit to a first value based on the condition of power storage unit and setting, when a temperature increase instruction (change instruction) is received after the start of charging, the target value to a predetermined second value higher than the first value, and a converter ECU for executing the charging process so that the state of charge of the power storage unit attains to the target value.

10 Claims, 8 Drawing Sheets

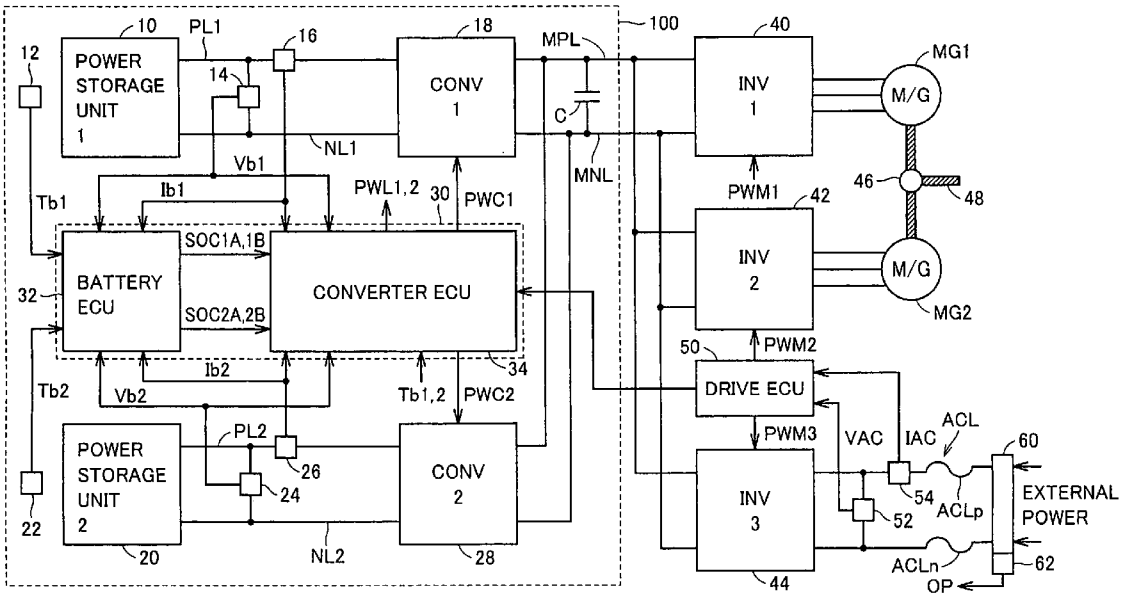


FIG.1

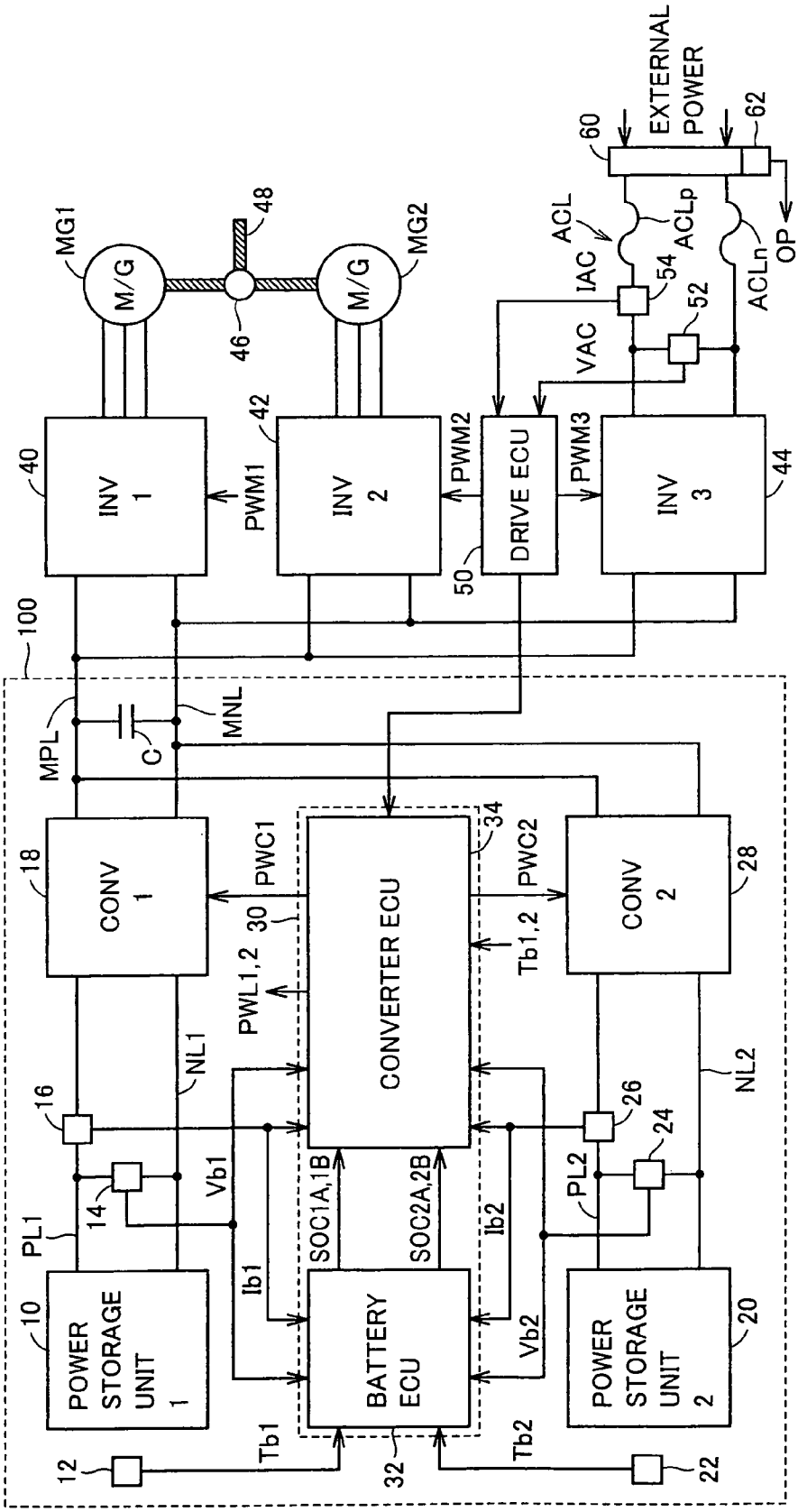

MG1
M/G
48
46
MG2
M/G
EXTERNAL POWER
60
62
ACL
IAC
54
ACLp
ACLn
OP
52
VAC
40
INV 1
PWM1
42
INV 2
PWM2
DRIVE ECU
50
PWM3
INV 3
44
100
MPL
C
MNL
18
CONV 1
PWC1
34
CONVERTER ECU
PWC2
CONV 2
28
30
PWL1,2
Tb1,2
NL1
NL2
16
26
24
Vb1
SOC1A,1B
SOC2A,2B
Ib2
PL2
14
PL1
Ib1
10
POWER STORAGE UNIT 1
BATTERY ECU
Vb2
POWER STORAGE UNIT 2
20
12
Tb1
32
Tb2
22

FIG.2

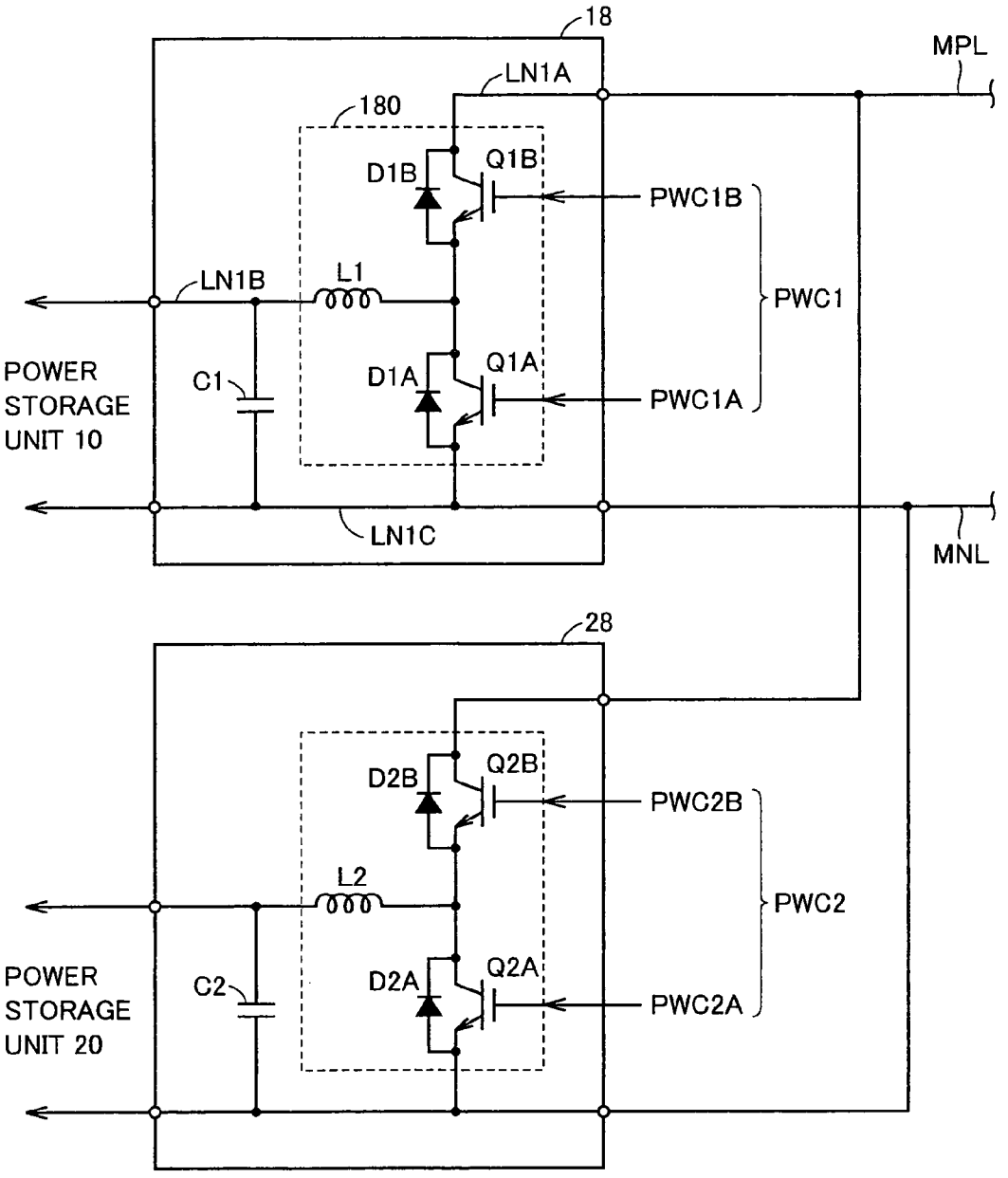

18
MPL
LN1A
180
D1B
Q1B
PWC1B
LN1B
L1
PWC1
POWER
STORAGE
UNIT 10
C1
D1A
Q1A
PWC1A
LN1C
MNL
28
D2B
Q2B
PWC2B
L2
PWC2
POWER
STORAGE
UNIT 20
C2
D2A
Q2A
PWC2A

FIG.3

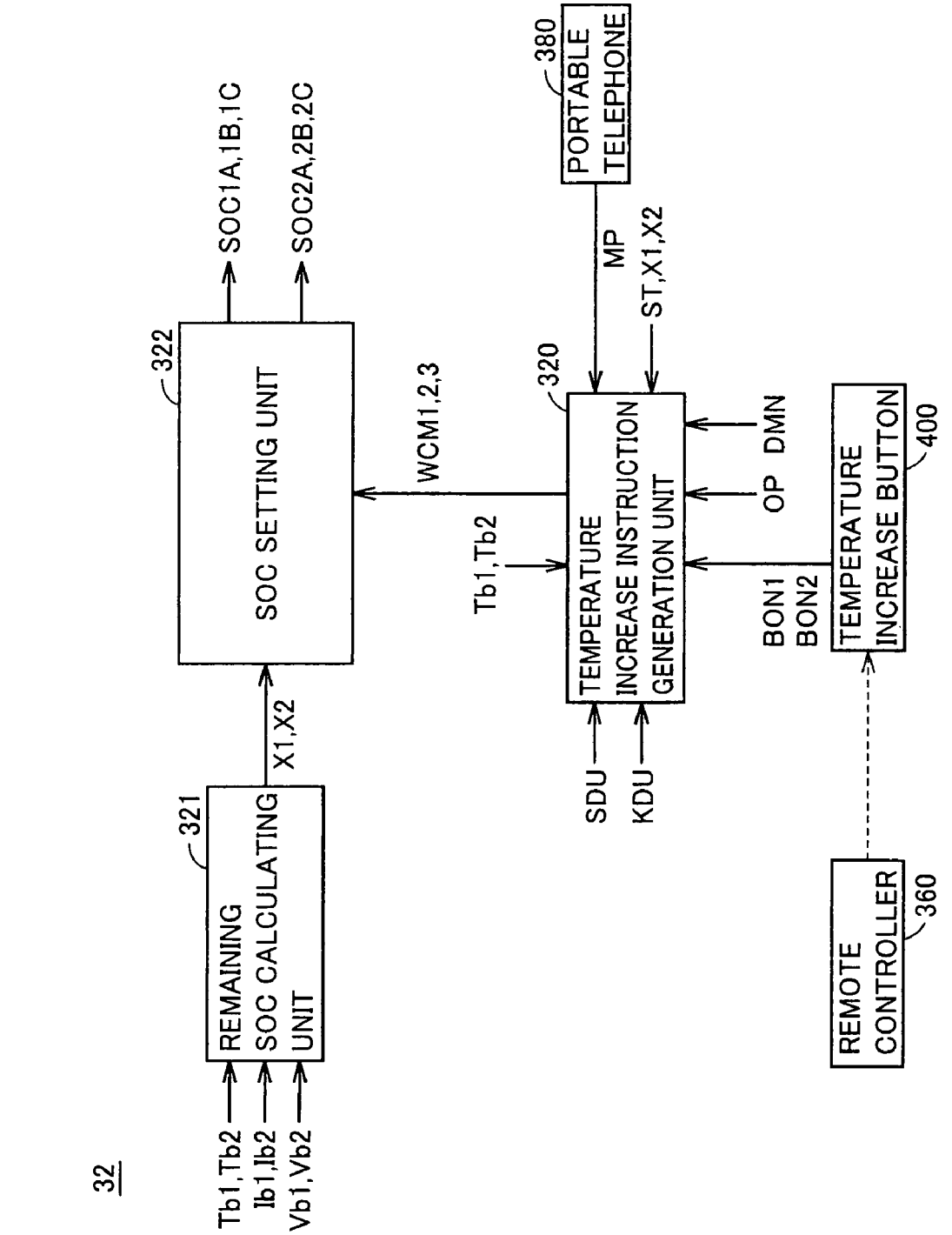
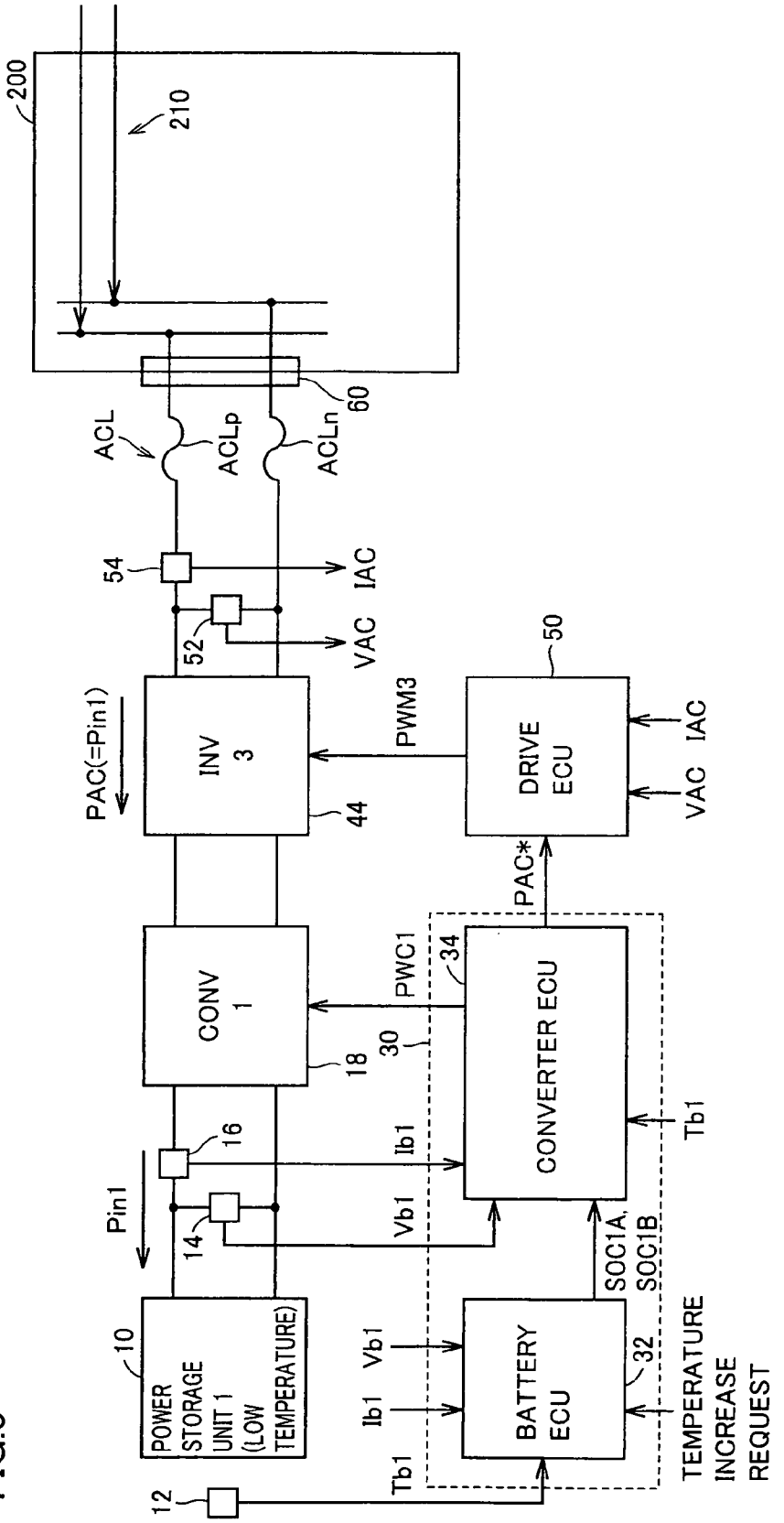

32
Tb1,Tb2
Ib1,Ib2
Vb1,Vb2
321
REMAINING SOC CALCULATING UNIT
X1,X2
322
SOC SETTING UNIT
SOC1A,1B,1C
SOC2A,2B,2C
WCM1,2,3
Tb1,Tb2
320
TEMPERATURE INCREASE INSTRUCTION GENERATION UNIT
SDU
KDU
380
PORTABLE TELEPHONE
MP
ST,X1,X2
OP DMN
BON1
BON2
TEMPERATURE INCREASE BUTTON
400
REMOTE CONTROLLER
360

FIG.4

INPUT SIGNAL
SMART DOOR UNLOCK SIGNAL (SDU)
KEYLESS DOOR UNLOCK SIGNAL (KDU)
MANUAL TEMPERATURE INCREASE BUTTON ON SIGNAL (BON1)
CHARGE CONNECTOR OPEN SIGNAL (OP)
REMOTE TEMPERATURE INCREASE BUTTON ON SIGNAL (BON2)
TEMPERATURE INCREASE REQUEST SIGNAL FROM HOUSE (DMN)
SIGNAL FROM PORTABLE TELEPHONE (MP)

FIG.5


200
210
60
ACL
ACLp
ACLn
54
IAC
52
VAC
PAC(=Pin1)
INV
3
44
PWM3
DRIVE
ECU
50
VAC
IAC
PAC*
CONV
1
18
PWC1
34
30
CONVERTER ECU
16
Ib1
Tb1
Pin1
14
Vb1
SOC1A,
SOC1B
10
POWER
STORAGE
UNIT 1
(LOW
TEMPERATURE)
Ib1
Vb1
BATTERY
ECU
32
Tb1
12
TEMPERATURE
INCREASE
REQUEST

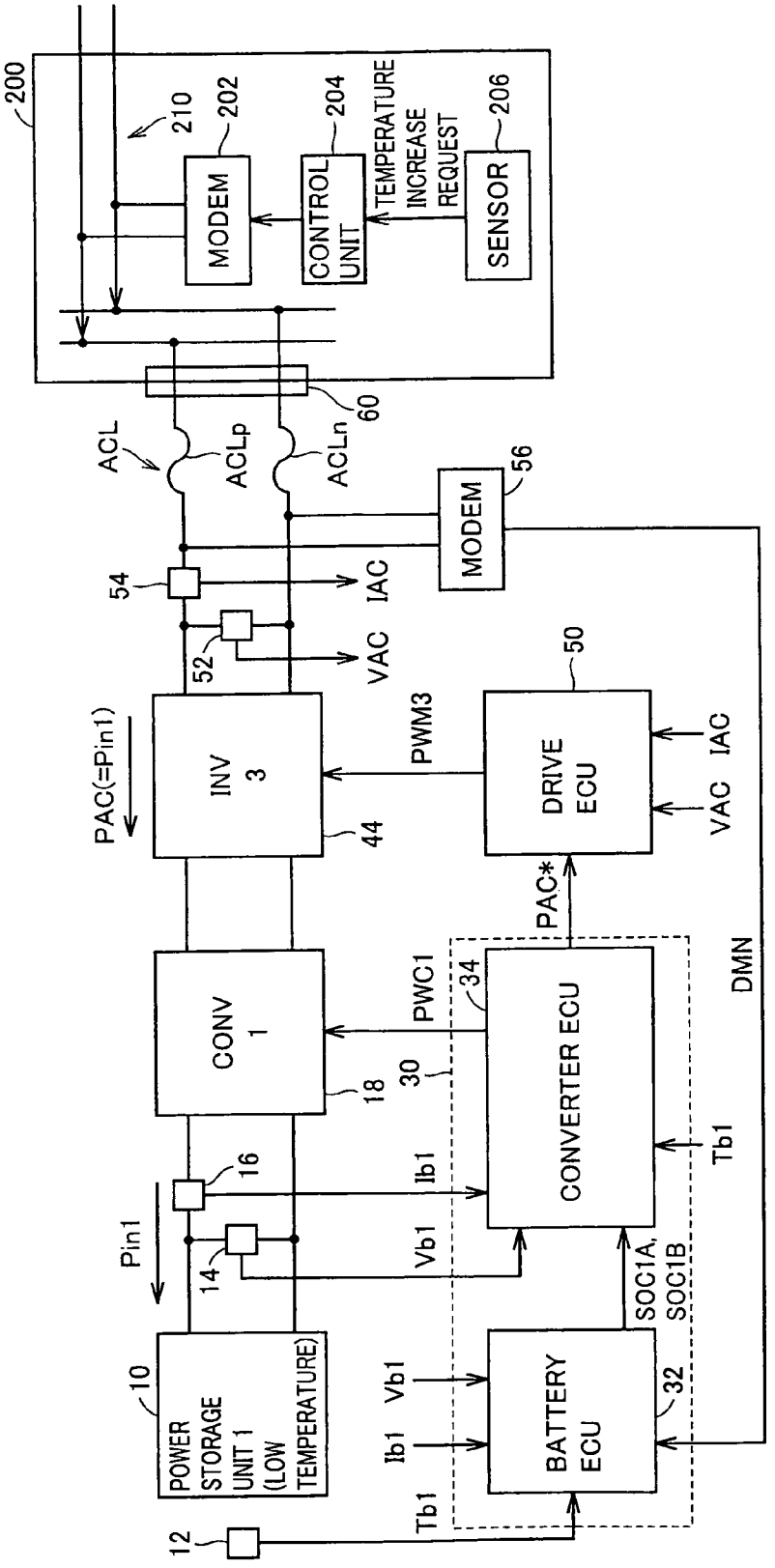

200
210
202
MODEM
204
CONTROL UNIT
TEMPERATURE INCREASE REQUEST
206
SENSOR
60
ACL
ACLp
ACLn
56
MODEM
54
IAC
52
VAC
PAC(=Pin1)
INV 3
PWM3
50
DRIVE ECU
IAC
VAC
44
PAC*
CONV 1
PWC1
34
CONVERTER ECU
DMN
18
30
16
Ib1
Tb1
Pin1
14
Vb1
SOC1A, SOC1B
10
POWER STORAGE UNIT 1 (LOW TEMPERATURE)
Vb1
Ib1
BATTERY ECU
32
Tb1
12

FIG.6

FIG.7

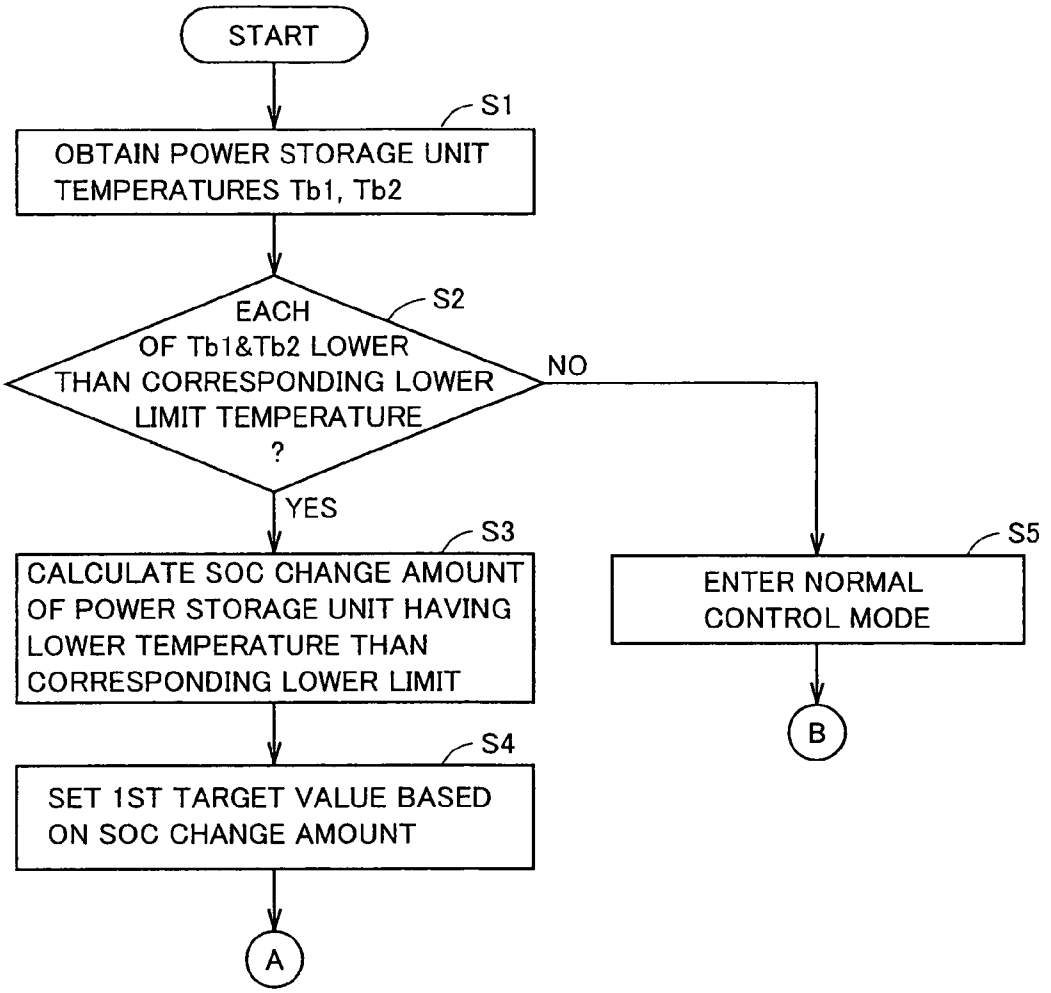
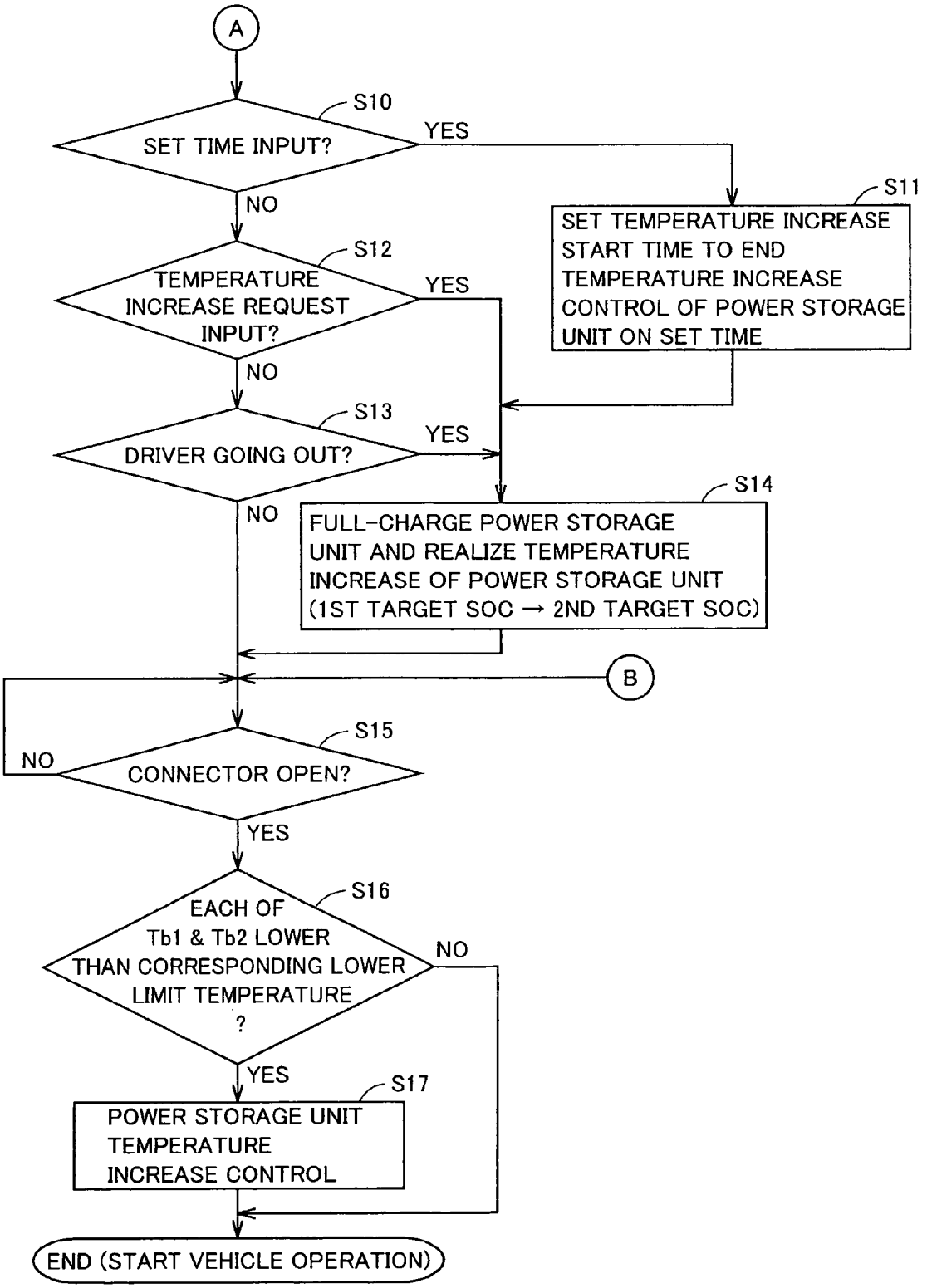

START
S1
OBTAIN POWER STORAGE UNIT TEMPERATURES Tb1, Tb2
S2
EACH OF Tb1&Tb2 LOWER THAN CORRESPONDING LOWER LIMIT TEMPERATURE ?
NO
YES
S3
CALCULATE SOC CHANGE AMOUNT OF POWER STORAGE UNIT HAVING LOWER TEMPERATURE THAN CORRESPONDING LOWER LIMIT
S4
SET 1ST TARGET VALUE BASED ON SOC CHANGE AMOUNT
A
S5
ENTER NORMAL CONTROL MODE
B

FIG.8


A
S10
SET TIME INPUT?
YES
NO
S11
SET TEMPERATURE INCREASE START TIME TO END TEMPERATURE INCREASE CONTROL OF POWER STORAGE UNIT ON SET TIME
S12
TEMPERATURE INCREASE REQUEST INPUT?
YES
NO
S13
DRIVER GOING OUT?
YES
NO
S14
FULL-CHARGE POWER STORAGE UNIT AND REALIZE TEMPERATURE INCREASE OF POWER STORAGE UNIT (1ST TARGET SOC → 2ND TARGET SOC)
B
S15
NO
CONNECTOR OPEN?
YES
S16
EACH OF Tb1 & Tb2 LOWER THAN CORRESPONDING LOWER LIMIT TEMPERATURE ?
NO
YES
S17
POWER STORAGE UNIT TEMPERATURE INCREASE CONTROL
END (START VEHICLE OPERATION)

POWER SUPPLY DEVICE AND VEHICLE INCLUDING THE SAME

TECHNICAL FIELD

The present invention relates to a power supply device and a vehicle including the same. More specifically, the present invention relates to a power supply device including a power storage unit, as well as to a vehicle including the same.

BACKGROUND ART

Recently, considering environmental issues, attention has been paid to a vehicle employing a motor as a drive power source, such as an electric vehicle, a hybrid vehicle and a fuel cell vehicle. Such a vehicle includes a power storage unit implemented, for example, by a secondary battery or an electric double layer capacitor for supplying electric power to the motor, and converting kinetic energy to electric energy during regenerative braking and storing such electric power.

In such a vehicle employing the motor as the drive force source, in order to enhance acceleration performance and running performance such as travel distance, greater charge/discharge capacity of the power storage unit is desired. Here, a configuration where a plurality of power storage units are mounted has been proposed as a method of increasing the charge/discharge capacity of the power storage unit.

On the other hand, as the power storage unit stores electric energy utilizing electrochemical action, charge/discharge characteristics thereof are susceptible to a temperature. A general power storage unit is lower in the charge/discharge performance as the temperature is lower. Accordingly, in order to maintain prescribed charge/discharge performance, temperature management, in particular temperature increase control, of the power storage unit is important.

For example, Japanese Patent Laying-Open No. 11-26032 discloses a heating-up device for a battery in an electric vehicle that raises a temperature of the battery mounted on the electric vehicle. According to this device, if a detected temperature of the battery is equal to or lower than a prescribed value when an instruction is issued from at least one of unlock detection means for detecting unlock of the vehicle, timer means for notification of a set time, and input means for input of operational information, control means carries out control such that an output current of the battery greater than a current required in the battery flows.

The heating-up device disclosed in Japanese Patent Laying-Open No. 11-26032 increases battery temperature by the discharge of battery. Therefore, electric power stored in the battery is undesirably wasted. The reference above, however, does not disclose any specific method to solve such a problem.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide a power supply device that can more reliably increase temperature of power storage unit while preventing decrease in energy efficiency.

In short, the present invention provides a power supply device mounted on a vehicle, including a power storage unit capable of being charged, and a control unit controlling charging of the power storage unit. The control unit includes a change instruction generation unit, a target value setting unit, and a charge processing unit. The change instruction generation unit generates a change instruction instructing change of state of charge of the power storage unit. The target value setting unit sets, when charging of the power storage unit starts, a target value of state of charge of the power storage unit to a first value based on the condition of the power storage unit, and sets, when the change instruction is received after the start of charging of the power storage unit, the target value to a second value higher than the first value. The charge processing unit executes a charging operation based on the target value.

Preferably, information representing the condition of the power storage unit is information of temperature around the power storage unit. The control unit further includes an amount of change calculating unit calculating an amount of change in state of charge of the power storage unit necessary to increase temperature of the power storage unit. The target value setting unit stores the second value in advance, and calculates the first value by subtracting the amount of change from the second value.

More preferably, the change instruction generation unit determines a start time of starting change of the state of charge of the power storage unit based on a designated charge end time and the amount of change, and when current time reaches the start time, generates the change instruction.

More preferably, the change instruction generation unit generates the change instruction in response to a temperature increase request input from outside.

More preferably, the change instruction generation unit outputs the change instruction when it receives the temperature increase request from a transmission device provided in a house. The transmission device transmits the temperature increase request in response to a result of detection by a sensor detecting a user going out from the house.

More preferably, the change instruction generation unit outputs the change instruction in response to a remote operation by a user.

According to another aspect, the present invention provides a vehicle, including a power supply device. The power supply device includes a power storage unit capable of being charged, and a control unit controlling charging of the power storage unit. The control unit includes a change instruction generation unit, a target value setting unit, and a charge processing unit. The change instruction generation unit generates a change instruction instructing change of state of charge of the power storage unit. The target value setting unit sets, when charging of the power storage unit starts, a target value of state of charge of the power storage unit to a first value based on the condition of the power storage unit, and sets, when the change instruction is received after the start of charging of the power storage unit, the target value to a second value higher than the first value. The charge processing unit executes a charging operation based on the target value.

Preferably, information representing the condition of the power storage unit is information of temperature around the power storage unit. The control unit further has an amount of change calculating unit calculating an amount of change in state of charge of the power storage unit necessary to increase temperature of the power storage unit. The target value setting unit stores the second value in advance, and calculates the first value by subtracting the amount of change from the second value.

More preferably, the change instruction generation unit determines a start time of starting change of the state of charge of the power storage unit based on a designated charge end time and the amount of change, and when current time reaches the start time, generates the change instruction.

More preferably, the change instruction generation unit generates the change instruction in response to a temperature increase request input from outside.

More preferably, the change instruction generation unit outputs the change instruction when it receives the temperature increase request from a transmission device provided in a house. The transmission device transmits the temperature increase request in response to a result of detection by a sensor detecting a user going out from the house.

More preferably, the change instruction generation unit outputs the change instruction in response to a remote operation by a user.

Therefore, according to the present invention, a power supply device that can more reliably increase the temperature of power storage device while preventing decrease in energy efficiency can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic configuration diagram showing a substantial part of a vehicle including a power supply device **100** according to an embodiment of the present invention.

FIG. **2** is a schematic configuration diagram of converters **18** and **28** according to an embodiment of the present invention.

FIG. **3** is a functional block diagram of a battery ECU **32** shown in FIG. **1**.

FIG. **4** illustrates signals input to a temperature increase instruction generation unit **320**.

FIG. **5** is a block diagram illustrating power supply from a commercial power supply to the power storage unit.

FIG. **6** illustrates a configuration of a house **200**, for transmitting a temperature increase request signal from house **200** of FIG. **5** to the vehicle.

FIG. **7** is a flowchart for realizing temperature increase control by a battery ECU **32** shown in FIG. **3**.

FIG. **8** is a flowchart for realizing temperature increase control by the battery ECU **32** shown in FIG. **3**.

BEST MODES FOR CARRYING OUT THE INVENTION

In the following, embodiments of the present invention will be described in detail with reference to the figures. In the figures, the same or corresponding portions are denoted by the same reference characters and description thereof will not be repeated.

[Vehicle Configuration]

FIG. **1** is a schematic configuration diagram showing a substantial part of a vehicle including a power supply device **100** according to an embodiment of the present invention.

Referring to FIG. **1**, the vehicle includes power supply device **100**, a first inverter (INV**1**) **40**, a second inverter (INV**2**) **42**, a third inverter (INV**3**) **44**, motor-generators MG**1**, MG**2**, and a drive ECU (Electrical Control Unit) **50**.

Inverters **40**, **42**, motor-generators MG**1**, MG**2**, and drive ECU **50** configure a drive force generation unit generating drive force of the vehicle. In the present embodiment, the vehicle runs by transmitting to wheels (not shown), drive force generated by electric power supplied to the drive force generation unit from power supply device **100**. In addition, during regeneration, the vehicle causes the drive force generation unit to generate electric power from kinetic energy and recovers the electric power in power supply device **100**.

In the present embodiment, power supply device **100** includes two power storage units. Power supply device **100** supplies and receives DC electric power to and from the drive force generation unit through a main positive bus MPL and a main negative bus MNL.

Inverters **40**, **42** are connected in parallel to main positive bus MPL and main negative bus MNL, and supply/receive electric power to/from power supply device **100**. That is, inverters **40**, **42** convert drive electric power (DC electric power) received through main positive bus MPL and main negative bus MNL to AC electric power and supply the AC electric power to motor-generators MG**1**, MG**2** respectively. In addition, inverters **40**, **42** convert AC electric power generated by motor-generators MG**1**, MG**2** to DC electric power and supply the resultant DC electric power as the regenerative electric power to power supply device **100**. By way of example, inverters **40**, **42** are constituted of a bridge circuit including switching elements of three phases, and generate three-phase AC electric power by performing a switching (circuit opening/closing) operation in response to switching instructions PWM**1**, PWM**2** received from drive ECU **50**.

Motor-generators MG**1**, MG**2** are configured to be able to generate rotational drive force by receiving AC electric power supplied from inverters **40**, **42** respectively and to be able to generate electric power by receiving external rotational drive force. For example, motor-generators MG**1**, MG**2** are implemented by a three-phase AC electric rotating machine including a rotor having permanent magnets embedded. Motor-generators MG**1**, MG**2** are coupled to a power split device **46**. The drive force generated at motor generators MG**1** and MG**2** are transmitted to wheels (not shown) via a drive shaft **48**.

If the drive force generation unit is applied to a hybrid vehicle, motor-generators MG**1**, MG**2** are also coupled to a not-shown engine through power split device **46** or drive shaft **48**. Then, drive ECU **50** carries out control such that an optimal ratio between the drive force generated by the engine and the drive force generated by motor-generators MG**1**, MG**2** is attained. If the drive force generation unit shown in FIG. **1** is applied to such a hybrid vehicle, motor-generator MG**1** may serve solely as the generator, while motor-generator MG**2** may serve solely as the motor.

Drive ECU **50** executes a program stored in advance. More specifically, drive ECU **50** calculates torque target values TR**1**, TR**2** and speed target values MRN**1**, MRN**2** of motor-generators MG**1**, MG**2**, based on a signal transmitted from each not-shown sensor, a running state, variation in an accelerator position, a stored map, or the like. Then, drive ECU **50** generates switching instructions PWM**1**, PWM**2** and controls inverters **40**, **42** such that generated torque and speed of motor-generators MG**1**, MG**2** attain torque target values TR**1**, TR**2** and speed target values MRN**1**, MRN**2** respectively. In addition, drive ECU **50** outputs calculated torque target values TR**1**, TR**2** and speed target values MRN**1**, MRN**2** to power supply device **100**.

In addition, in the present embodiment, inverter **44** is connected to main positive bus MPL and main negative bus MNL, in parallel to inverters **40**, **42**. Inverter **44** is further electrically connected to a commercial power supply (not shown) in a house outside the vehicle through a supply line ACL and a charge connector **60** such that electric power can be supplied and received to and from the commercial power supply.

Receiving commercial electric power supplied from the outside of the vehicle through charge connector **60** and supply line ACL, inverter **44** generates DC electric power for supply to power supply device **100**. For example, inverter **44** is implemented by a single-phase inverter so as to adapt to electric power used in the house (not shown) outside the vehicle.

A supply current detection unit **54** inserted in a positive supply line ACLp detects a supply current IAC from the commercial power supply and outputs the detected value to

drive ECU **50**. In addition, a supply voltage detection unit **52** connected between positive supply line ACLp and a negative supply line ACLn detects a supply voltage VAC from the commercial power supply and outputs the detected value to drive ECU **50**.

In addition, an opening and closing detection unit **62** detects opening of charge connector **60**, that is, electrical disconnection between the vehicle and the commercial power supply. Opening and closing detection unit **62** outputs a signal OP indicating the detected result to power supply device **100**.

[Configuration of Power Supply Device]

Power supply device **100** includes a smoothing capacitor C, a first converter (CONV**1**) **18**, a second converter (CONV**2**) **28**, a first power storage unit **10**, a second power storage unit **20**, charge/discharge current detection units **16**, **26**, charge/discharge voltage detection units **14**, **24**, temperature detection units **12**, **22**, and a control unit **30**. Control unit **30** includes a battery ECU **32** and a converter ECU **34**.

Smoothing capacitor C is connected between main positive bus MPL and main negative bus MNL, and reduces a fluctuating component contained in drive electric power output from converters **18**, **28** and regenerative electric power output from the drive force generation unit.

Converters **18**, **28** are provided between main positive bus MPL, main negative bus MNL and power storage units **10**, **20**, and perform a voltage conversion operation between power storage units **10**, **20** and main positive bus MPL, main negative bus MNL, respectively. More specifically, converters **18**, **28** boost discharge electric power from power storage units **10**, **20** to a prescribed voltage for supply as drive electric power, while they down-convert regenerative electric power supplied from the drive force generation unit to a prescribed voltage for charging power storage units **10**, **20**. For example, converters **18**, **28** are implemented by a boost/buck chopper circuit.

Power storage units **10**, **20** are connected in parallel to main positive bus MPL and main negative bus MNL with converters **18**, **28** being interposed respectively. For example, power storage unit **10**, **20** is implemented by a secondary battery configured to be capable of charge/discharge, such as a nickel metal hydride battery or a lithium-ion battery, or by an electric double layer capacitor.

Charge/discharge current detection units **16**, **26** are inserted in the power lines connecting power storage units **10**, **20** to converters **18**, **28** respectively, detect charge/discharge current values Ib**1**, Ib**2** used in charge/discharge of power storage units **10**, **20** respectively, and output the result of detection to battery ECU **32** and converter ECU **34**.

Charge/discharge voltage detection units **14**, **24** are connected between the power line connecting power storage unit **10** to converter **18** and the power line connecting power storage unit **20** to converter **28**, respectively, detect charge/discharge voltage values Vb**1**, Vb**2** of power storage units **10**, **20** respectively, and output the result of detection to control unit **30** (battery ECU **32** and converter ECU **34**).

Temperature detection units **12**, **22** are arranged in the proximity of battery cells and the like constituting power storage units **10**, **20** respectively, detect power storage unit temperatures Tb**1**, Tb**2** which represent ambient temperatures of power storage units **10**, **20**, and output the result of detection to battery ECU **32**. It is noted that temperature detection units **12**, **22** may be configured to output a representative value obtained for example by averaging processing, based on the result of detection by a plurality of detection elements arranged in correspondence with a plurality of battery cells constituting power storage units **10**, **20**. Though it is preferable to provide temperature detection units **12** and **22** in the vicinity of power storage units **10** and **20**, respectively, these may be arranged, for example, to detect temperature outside the vehicle.

Battery ECU **32** calculates SOC (State of Charge) in respective power storage units **10**, **20**, based on charge/discharge current values Ib**1**, Ib**2** received from charge/discharge current detection units **16**, **26**, charge/discharge voltage values Vb**1**, Vb**2** received from charge/discharge voltage detection units **14**, **24**, and power storage unit temperatures Tb**1**, Tb**2** received from temperature detection units **12**, **22**.

Battery ECU **32** determines whether the temperature of power storage units **10**, should be raised or not based on power storage unit temperatures Tb**1**, Tb**2** received from temperature detection units **12**, **22**, respectively. Specifically, battery ECU **32** determines whether each of power storage unit temperatures Tb**1**, Tb**2** is lower than a corresponding lower limit temperature (such as −15° C.). Then, battery ECU **32** carries out temperature increase control of the power storage unit of which temperature is lower than the corresponding lower limit temperature.

Battery ECU **32** sets SOC target value of power storage unit **10** to SOC**1**A before starting temperature increase of power storage unit **10**. When temperature increase of power storage unit **10** is to be started, battery ECU **32** changes the SOC target value from SOC**1**A to SOC**1**B. Similarly, battery ECU **32** sets target SOC of power storage unit **20** to SOC**2**A before starting temperature increase of power storage unit **20**. When temperature increase of power storage unit **20** is to be started, battery ECU **32** changes the SOC target value from SOC**2**A to SOC**2**B.

It is noted that SOC**1**A<SOC**1**B, and SOC**2**A<SOC**2**B. Further, the values of SOC**1**B and SOC**2**B are set to a prescribed value (for example, 80%) with which power storage units **10** and **20** are almost fully charged.

Converter ECU **34** generates drive signals PWC**1** and PWC**2** for driving converters **18** and **28**, respectively, based on charge/discharge currents Ib**1**, Ib**2**, charge/discharge voltages Vb**1**, Vb**2**, temperatures Th**1**, Tb**2** of power storage units, SOC (SOC**1**A, SOC**1**B, SOC**2**A, SOC**2**B) from battery ECU **32** and the like. Converters **18** and **28** are controlled by drive signals PWC**1** and PWC**2**, respectively. Accordingly, external electric power is supplied through converters **18** and **28** to power storage units **10** and **20**, respectively. Thus, power storage units **10** and **20** can be charged.

When the SOC target value of power storage unit **10** is SOC**1**B, converter ECU **34** controls converter **18** in accordance with the target value. Here, the temperature of power storage unit **10** increases as power storage unit **10** is charged. The same applies to power storage unit **20**, and when the target SOC value of power storage unit **20** is SOC**2**B, converter ECU **34** controls converter **28** in accordance with the target value. Here, the temperature of power storage unit **20** increases as power storage unit **20** is charged.

FIG. **2** is a schematic configuration diagram of converters **18**, **28** according to the embodiment of the present invention.

Referring to FIG. **2**, converter **18** is constituted of a chopper circuit **180** and a smoothing capacitor C**1**.

Chopper circuit **180**, during discharge, boosts the DC electric power received from power storage unit **10** in response to switching instruction PWC**1** from converter ECU **34**, while chopper circuit **180**, during charging, down converts the DC electric power received through main positive bus MPL and main negative bus MNL. Chopper circuit **180** includes a positive bus LN**1**A, a negative bus LN**1**C, a line LN**1**B, transistors Q**1**A, Q**1**B representing a switching element, diodes D**1**A, D**1**B, and an inductor L**1**.

Positive bus LN1A has one end connected to a collector of transistor Q1B and the other end connected to main positive bus MPL. In addition, negative bus LN1C has one end connected to a negative side of power storage unit **10** and the other end connected to main negative bus MNL.

Transistors Q1A, Q1B are connected in series between negative bus LN1C and positive bus LN1A. Transistor Q1A has an emitter connected to negative bus LN1C and transistor Q1B has the collector connected to positive bus LN1A. In addition, diodes D1A, D1B allowing current flow from the emitter side to the collector side are connected between the collector and the emitter of transistors Q1A, Q1B respectively. Further, inductor L1 is connected to a connection point of transistor Q1A and transistor Q1B.

Line LN1B has one end connected to the positive side of power storage unit **10** and the other end connected to inductor L1.

Smoothing capacitor C1 is connected between line LN1B and negative bus LN1C, and reduces the AC component contained in the DC voltage across line LN1B and negative bus LN1C.

The voltage conversion operation (boost operation and down-converting operation) of converter **18** will be described hereinafter. In the boost operation, converter ECU **34** maintains transistor Q1B in the ON state, and turns on/off transistor Q1A at a prescribed duty ratio. During the ON period of transistor Q1A, a discharge current flows from power storage unit **10** to main positive bus MPL sequentially through line LN1B, inductor L1, diode D1B, and positive bus LN1A. At the same time, a pump current flows from power storage unit **10** sequentially through line LN1B, inductor L1, transistor Q1A, and negative bus LN1C. Inductor L1 accumulates electromagnetic energy by means of the pump current. Successively, when transistor Q1A makes transition from the ON state to the OFF state, inductor L1 superimposes the accumulated electromagnetic energy onto the discharge current. Consequently, the average voltage of the DC electric power supplied from converter **18** to main positive bus MPL and main negative bus MNL is boosted by a voltage corresponding to the electromagnetic energy accumulated in inductor L1 in accordance with the duty ratio.

On the other hand, in the down-converting operation, converter ECU **34** turns on/off transistor Q1B at a prescribed duty ratio, and maintains transistor Q1A in the OFF state. During the ON period of transistor Q1B, the charge current flows from main positive bus MPL to power storage unit **10** sequentially through positive bus LN1A, transistor Q1B, inductor L1, and line LN1B. Successively, when transistor Q1B makes transition from the ON state to the OFF state, magnetic flux is generated to prevent current variation in inductor L1. Accordingly, the charge current continues to flow sequentially through diode D1A, inductor L1 and line LN1B. Meanwhile, from a viewpoint of electric energy, it is solely during the ON period of transistor Q1B that the DC electric power is supplied through main positive bus MPL and main negative bus MNL. Therefore, if the charge current is maintained constant (if inductance of inductor L1 is sufficiently large), the average voltage of the DC electric power supplied from converter **18** to power storage unit **10** is set to a value obtained by multiplying the DC voltage across main positive bus MPL and main negative bus MNL by the duty ratio.

In order to control such a voltage conversion operation of converter **18**, converter ECU **34** generates switching instruction PWC1 consisting of a switching instruction PWC1A controlling on/off of transistor Q1A and a switching instruction PWC1B controlling on/off of transistor Q1B.

As the configuration and the operation of converter **28** are also similar to those of converter **18** described above, detailed description will not be repeated.

[Structure of Battery ECU]

FIG. **3** is a functional block diagram of battery ECU **32** shown in FIG. **1**. The functions of various blocks shown in FIG. **3** may be implemented by hardware or software.

Referring to FIG. **3**, battery ECU **32** includes a temperature increase instruction generation unit **320**, a remaining SOC calculating unit **321**, and an SOC setting unit **322**.

Temperature increase instruction generation unit **320** determines whether temperature increase control of power storage units **10** and **20** is necessary, based on power storage unit temperatures Tb1, Tb2 from temperature detection units **12** and **22**, respectively. More specifically, temperature increase instruction generation unit **320** determines whether each of power storage unit temperatures Tb1, Tb2 is lower than the corresponding lower limit temperature or not. When it is determined that the temperature of either one of power storage units **10**, **20** is lower than the corresponding lower limit temperature, temperature increase instruction generation unit **320** generates the temperature increase instruction for the power storage unit of which temperature is lower than the corresponding lower limit temperature, when a signal input from the outside of the vehicle is received, or when the current time has reached a temperature increase start time.

If both of power storage unit temperatures Tb1, Tb2 are lower than the corresponding lower limit temperature, temperature increase instruction generation unit **320** generates the temperature increase instruction for the power storage unit higher in priority out of power storage units **10**, **20**. Here, priority is decided in accordance with a full charge capacity of the power storage unit, SOC of the power storage unit, and an amount of deviation of the power storage unit temperature from a prescribed operation temperature range.

As will be described later, the signal input to temperature increase instruction generation unit **320** includes signals SDU, KDU indicating that a door of the vehicle has been unlocked with a wireless door lock mechanism equipped in the vehicle, signals BON1, BON2 indicating a state of operation of a temperature increase button **400** provided in the vicinity of a driver's seat in the vehicle, signal OP indicating that charge connector **60** has been opened, a signal DMN indicating a temperature increase request from a not-shown house, and an output signal MP from a portable telephone **380**. As the information necessary for determining the temperature increase start time, an amount of change X1 in SOC of power storage unit **10**, an amount of change X2 in SOC of power storage unit **20**, and a charge end time (set time ST) set by the user, are input to temperature increase instruction generation unit **320**.

Remaining SOC calculating unit **321** calculates the amount of change X1 of SOC necessary for increasing temperature of power storage unit **10**, based on the temperature T1*b* of power storage unit **10**. Remaining SOC calculating unit **321** sets the amount of change X1 based on a difference between the power storage unit temperature Tb1 and the lower limit temperature of power storage unit **10**.

By way of example, remaining SOC calculating unit **321** stores a map defining correspondence of the amount of change X1 to the difference between the power storage unit temperature Tb1 and the lower limit temperature of power storage unit **10**, and it may determine the amount of change X1 by looking up the map. Alternatively, remaining SOC calculating unit **321** stores in advance SOC1B as the SOC of power storage unit **10** in the fully charged state, and it may calculate current SOC of power storage unit **10** based on the

power storage unit temperature Tb1, charge/discharge current value Ib1 and charge/discharge voltage value Vb1. Here, if the difference between SOC1B and the current SOC of power storage unit **10** is larger than the amount of change X1 calculated from the map, remaining SOC calculating unit **321** sets the difference as the amount of change X1. The amount of change X2 is calculated in the similar manner as that for X1.

SOC setting unit **322** sets the target SOC value to be applied to converter ECU **34** shown in FIG. **1**. SOC setting unit **322** sets the target SOC value of power storage unit **10** to SOC1A (for example, 50%) that is lower by the amount of change X1 (for example, 30%) from SOC1B (for example, 80%), before receiving the temperature increase instruction WCM1 from temperature increase instruction generation unit **320**. After receiving temperature increase instruction WCM1, SOC setting unit **322** sets the SOC target value to SOC1B.

When the temperature of power storage unit **20** is to be increased, SOC setting unit **322** performs an operation similar to that described above. The operation corresponds to the above-described operation with temperature increase instruction WCM1 changed to temperature increase instruction WCM2, SOC1A to SOC2A and SOC1B to SOC2B.

FIG. **4** shows signals input to temperature increase instruction generation unit **320**.

Referring to FIGS. **3** and **4**, seven signals in total are input to temperature increase instruction generation unit **320**.

The first and second input signals are smart door unlock signal SDU and keyless door unlock signal KDU. These signals are signals transmitted from a body ECU (not shown) controlling lock/unlock of the door to temperature increase instruction generation unit **320** as the signal indicating unlock of the door when the door of the vehicle is unlocked as a result of matching between an ID code included in a signal transmitted from a wireless transmitter contained in the key and an ID code provided to the vehicle, in the vehicle provided with a wireless door lock mechanism.

Specifically, smart door unlock signal SDU is adapted to what is called a "smart entry system," which is a function to allow lock/unlock of the door of the vehicle or start of the engine without using a mechanical key and represents one form of the wireless door lock mechanism. More specifically, when the smart door unlock function included in the smart entry system (for example, a function to unlock the door when the user carrying the smart key holds a handle outside the driver's seat in a sensing area outside the vehicle) is actuated, the body ECU generates smart door unlock signal SDU and transmits the signal to temperature increase instruction generation unit **320**.

In addition, keyless door unlock signal KDU is adapted to a keyless entry system representing another form of the wireless door lock mechanism. More specifically, the body ECU generates keyless door unlock signal KDU and transmits the signal to temperature increase instruction generation unit **320** in response to unlock of the door as a result of actuation of the wireless remote control function contained in the key.

The third input signal is the signal BON1 indicating that temperature increase button **400** is set to the ON state by a manual operation by the user. Temperature increase button **400** is provided in the vicinity of the driver's seat in the vehicle, and it is set to ON as a result of the user's manual operation or remote operation through the remote controller. Then, temperature increase button **400** transmits the temperature increase request from the user to temperature increase instruction generation unit **320** in response to setting to ON.

The fourth input signal is the signal OP indicating that charge connector **60** shown in FIG. **1** has been opened (hereinafter also referred to as the charge connector opening signal). For example, charge connector opening signal OP is generated in response to removal of charge connector **60** from a power outlet provided on the house side by the user before the user uses the vehicle. Generated charge connector opening signal OP is transmitted from opening and closing detection unit **62** provided in charge connector **60** to temperature increase instruction generation unit **320**.

The fifth input signal is the signal BON2 indicating that temperature increase button **400** is set to the ON state by a remote operation using a remote controller **360** by the user.

The sixth input signal is the temperature increase request signal DMN generated by the user in the house to the vehicle. By way of example, temperature increase request signal DMN is issued when starting capability of the vehicle in an environment at a low temperature is desirably ensured by warming the power storage unit in advance before the user uses the vehicle.

The seventh input signal is the output signal MP from portable telephone **380**. Generally, a user more often operates portable telephone **380** than remote controller **360**. Therefore, if temperature increase instruction generation unit **320** can be activated to generate the temperature increase instruction by the user operating portable telephone **380**, it would be more convenient for the user.

In response to these input signals, temperature increase instruction generation unit **320** generates a temperature increase instruction (WCM1 or WCM2) for the power storage unit of which temperature is lower than the corresponding lower limit temperature, and outputs it to SOC setting unit **322**.

[Temperature Increase Control Process]

As described above, in the present embodiment, power is exchanged between the commercial power supply and the power storage unit. Therefore, in the present embodiment, it becomes possible to increase the temperature of power storage unit without consuming electric power of the power storage unit. In the following, temperature increase control in accordance with the present embodiment will be described.

In the following description, however, an example will be described in which temperature Tb1 of power storage unit **10** is lower than the lower limit value and hence temperature of power storage unit **10** is increased. The same operation as will be described in the following is performed to increase the temperature of power storage unit **20**.

FIG. **5** is a block diagram illustrating power supply from the commercial power supply to the power storage unit.

Referring to FIG. **5**, the vehicle is connected to a power outlet of house **200** by a charge connector **60** through supply line ACL. To the vehicle, commercial power supplied through commercial power supply line **210** to house **200** is applied. At this time, power storage unit **10** as the object of temperature increase is charged by the commercial power from house **200**. Therefore, power storage unit **10** has its temperature increased because of self heat generation.

More specifically, when charge connector **60** is coupled to the power outlet of house **200**, supply line ACL and commercial power supply line **210** are electrically connected.

Converter ECU **34** generates a switching instruction PWC1 of converter **18** that corresponds to the power storage unit **10** as the object of temperature increase. Converter ECU **34** determines a target supply power PAC* for the commercial power supply, and outputs it to drive ECU **50**.

Drive ECU **50** generates a switching instruction PWM3 of inverter **44**, based on the applied target supply power PAC*. Consequently, power exchange between the commercial power supply and power storage unit **10** as the object of temperature increase starts.

First, battery ECU **32** sets the target SOC value of power storage unit **10** to SOC**1**A. Converter ECU **34** controls converter **18** such that the SOC value of power storage unit **10** attains to SOC**1**A. Specifically, converter ECU **34** determines a target charge/discharge power P**1*** of power storage unit **10** based on SOC**1**A. Then, based on power difference between the determined target charge/discharge power P**1*** and the charge/discharge power P**1** of power storage unit **10**, converter ECU **34** generates the switching instruction PWC**1** for converter **18**.

Further, converter ECU **34** determines the target supply power PAC* for the commercial power supply to be the charge power Pin**1** for power storage unit **10**, and outputs the target supply power PAC* to drive ECU **50**. Based on power difference between the applied target supply power PAC* and the actual value of supplied power PAC, drive ECU **50** generates a switching instruction PWM**3** of inverter **44**. It is noted that the actual value of supply power PAC is calculated by multiplying the supplied current IAC from supply current detection unit **54** by the supplied voltage VAC from supply voltage detection unit **52**.

Receiving the temperature increase request (smart door unlock signal SDU, keyless door unlock signal KDU or the like), battery ECU **32** changes the target SOC value to be output to converter ECU**34** from SOC**1**A to SOC**1**B. Then, converter ECU **34** controls converter **18** such that the SOC value of power storage unit **10** attains to SOC**1**B. Here, converter ECU**34** changes the target charge/discharge power P**1*** of power storage unit **10** based on SOC**1**B, and based on power difference between the target charge/discharge power P**1*** and the charge/discharge power of power storage unit **10**, changes the switching instruction PWC**1**. Further, converter ECU**34** changes the target supply power PAC* (charge power Pin**1** to power storage unit **10**), and outputs the target supply power PAC* to drive ECU **50**. Based on power difference between the applied target supply power PAC* and the actual value of supply power PAC, drive ECU **50** generates a switching instruction PWM**3** of inverter **44**. Accordingly, the temperature of power storage unit **10** increases as power storage unit **10** is charged.

FIG. **6** illustrates a configuration of house **200**, for transmitting the temperature increase request signal from house **200** shown in FIG. **5** to the vehicle.

Referring to FIGS. **6** and **5**, when temperature increase control from house **200** to power storage unit **100** is to be executed, a modem **202**, a control unit **204** and a sensor **206** are additionally installed in house **200** shown in FIG. **5**.

Modem **202** transmits/receives information to/from a vehicle that is electrically connected. Modem **202** is connected between lines of commercial power supply **210**, modulates information signal applied from control unit **204** and superposes the result on a current flowing through commercial power supply line **210**, and extracts a modulated signal included in the current flowing through power supply line **210**, demodulates the signal to information signal, and outputs the result to control unit **204**.

Control unit **204** is capable of managing the state of charge of power storage unit of the vehicle through transmission/reception of information to/from the vehicle, and capable of receiving the temperature increase request from sensor **206**. When a temperature increase request is applied from sensor **206**, control unit **204** transmits the temperature increase request signal DMN to the vehicle through modem **202**.

Sensor **206** outputs the temperature increase request when, for example, the user going out is detected. Various sensors may be used as sensor **206**. For example, if sensor **206** is a sensor for detecting opening/closing of front door, sensor **206** outputs the temperature increase request when the user opens/closes the front door.

In the vehicle, modem **56** is connected between positive supply line ACLp and negative supply line ACLn, enabling transmission/reception of information to/from house **200**. Receiving the temperature request signal DMN transmitted from house **200** via modem **56**, battery ECU **32** changes the target SOC value output to converter ECU **34** from SOC**1**A to SOC**1**B.

FIGS. **7** and **8** are flowcharts for realizing the temperature increase control by battery ECU **32** shown in FIG. **3**. The process of the flowcharts are called from a prescribed main routine and executed at every constant time interval or every time prescribed conditions are satisfied.

Referring to FIGS. **7** and **3**, temperature increase instruction generation unit **320** and remaining SOC calculating unit **321** obtain power storage unit temperatures Tb**1** and Tb**2** from temperature detection units **12** and **22** (step S**1**). Temperature increase instruction generation unit **320** determines whether each of the obtained power storage unit temperatures Tb**1** and Tb**2** is lower than the corresponding lower limit temperature (step S**2**).

If either one of power storage unit temperatures Tb**1** and Tb**2** is lower than the corresponding lower limit temperature (YES at step S**2**), remaining SOC calculating unit **321** calculates the amount of change of SOC (remaining SOC) that is necessary to increase the temperature (step S**3**). Remaining SOC calculating unit **321** calculates the amount of change (amounts of change X**1**, X**2**) of SOC necessary to increase the temperature of power storage unit as the object of temperature increase, based on the current temperature of the power storage unit.

If both of power storage unit temperatures Tb**1** and Tb**2** are lower than the corresponding lower limit temperatures, remaining SOC calculating unit **321** calculates the amount of change for the power storage unit of higher priority.

Further, at step S**3**, temperature increase instruction generation unit **320** determines the temperature increase instruction to be output, of temperature increase instructions WCM**1** and WCM**2**, based on power storage unit temperatures Tb**1** and Tb**2**.

In the following, by way of example, temperature increase control of power storage unit **10** will be described. SOC setting unit **322** determines the target SOC value of power storage unit **10**, that is, SOC**1**A (first target SOC), based on the amount of change X**1** (remaining SOC) applied from remaining SOC calculating unit **321** (step S**4**). At step S**4**, SOC setting unit **322** determines SOC**1**A by subtracting X**1** from the second target value SOC (SOC**1**B) of power storage unit **10**.

If power storage unit temperatures Tb**1** and Tb**2** are both not lower than the corresponding lower limit temperatures at step S**2** (NO at step S**2**), battery ECU **32** enters normal operation mode (step S**5**). Then, battery ECU **32** executes a process of step S**15**, which will be described later. Here, the "normal operation mode" means the control mode in which the power storage unit is charged without temperature increase control. In that case, SOC setting unit **322** sets only the second target SOC.

Next, referring to FIGS. **8** and **3**, the process after step S**4** will be described. Temperature increase instruction generation unit **320** determines whether there has been a user input of set time ST (step S**1**). If there has been an input of set time ST (YES at step S**10**), temperature increase instruction generation unit **320** sets a temperature increase start time of power storage unit **10** such that temperature increase control

of power storage unit **10** ends (power storage unit **10** attains to the fully charged state) at the set time ST (step S**11**). As already described, the temperature increase start time is determined based on the amount of change X**1** of SOC and on the set time ST.

For instance, temperature increase instruction generation unit **320** stores in advance the time-change rate of SOC of power storage unit **10** when a prescribed charging current is caused to flow. Temperature increase instruction generation unit **320** determines the temperature increase start time based on the amount of change X**1**, the time-change rate, and the set time ST. Other method of determining temperature increase start time may be available.

When the current time reaches the temperature increase start time, temperature increase instruction generation unit **320** outputs temperature increase instruction WCM**1** and ends the process of step S**11**. When the process of step S**11** ends, the process of step S**14**, which will be described later, is executed.

If there is no input of set time ST (NO at step S**10**), temperature increase instruction generation unit **320** determines whether there is an input of temperature increase request from outside (step S**12**). Here, "outside" means outside of the battery ECU **32**. Further, "input of temperature increase request" means input of any of smart door unlock signal SDU, keyless door unlock signal KDU, signals BON**1** and BON**2** from temperature increase button **400** and output signal MP from portable telephone **380**, to temperature increase instruction generation unit **320**. When there is an input of temperature increase request (YES at step S**12**), temperature increase instruction generation unit **320** outputs temperature increase instruction WCM**1** and executes the process of step S**14**. If there is no input of temperature increase request to temperature increase instruction generation unit **320** (NO at step S**12**), temperature increase instruction generation unit **320** executes the process of step S**13**.

At step S**13**, temperature increase instruction generation unit **320** determines whether the driver (user) goes out or not. As described above, if the driver goes out, a temperature increase request is transmitted from a sensor **206** provided in house **200** to control unit **204**. Receiving the temperature increase request, control unit **204** controls modem **202** and causes modem **202** to output temperature increase request signal DMN. Temperature increase instruction generation unit **320** receives the temperature increase request signal DMN via modem **56**. Specifically, determination as to whether the driver (user) goes out or not by temperature increase instruction generation unit **320** corresponds to determination as to whether there is an input of temperature increase request signal DMN or not, by temperature increase instruction generation unit **320**.

If temperature increase request signal DMN is input to temperature increase instruction generation unit **320** (YES at step S**13**), temperature increase instruction generation unit **320** outputs temperature increase instruction WCM**1**, and thereafter executes the process of step S**14**. If temperature increase request signal DMN is not input to temperature increase instruction generation unit **320** (NO at step S**13**), temperature increase instruction generation unit **320** executes the process of step S**15**, which will be described later.

At step S**14**, SOC setting unit **322** receives temperature increase instruction WCM**1** and changes the target SOC value from SOC**1**A (first target value) to SOC**1**B (second target value). Consequently, power storage unit **10** is charged until it reaches the fully charged state, and temperature increase of power storage unit **10** is realized.

At step S**15**, temperature increase instruction generation unit **320** determines whether or not charge connector **60** has been opened. That the charge connector **60** is opened means end of charging from commercial power supply to power storage unit **10**. Temperature increase instruction generation unit **320** executes the process of step S**16** if it receives a signal OP (YES at step S**15**), and otherwise (NO at step S**15**), it repeats the determination process of step S**15**.

At step S**16**, temperature increase instruction generation unit **320** determines whether or not each of the power storage unit temperatures Tb**1** and Tb**2** is lower than the corresponding lower limit temperature. If the temperature of power storage unit at the start of temperature increase is significantly lower than the lower limit, or if the power storage unit has high thermal capacity, it is possible that both power storage unit temperatures Tb**1** and Tb**2** are lower than the corresponding lower limit temperatures even after the power storage units are charged to the full charged state at step S**14**.

By way of example, if the temperature Tb**1** of power storage unit **10** is lower than the lower limit temperature (YES at step S**16**), temperature increase instruction generation unit **320** outputs a temperature increase instruction WCM**3** for further increasing the temperature Tb**1** of power storage unit **10** (step S**17**). Then, SOC setting unit **322** changes the SOC target value from SOC**1**B to SOC**1**C (where SOC**1**B>SOC**1**C). As a result, power storage unit **10** is discharged, and heat generates in power storage unit **10**. Thus, the temperature of power storage unit **10** can further be increased.

If the process of step S**17** takes place, part of electric power stored in power storage unit **10** is consumed, for example, by converter **18**, inverter **3** and the like. In most cases, however, the temperature Tb**1** of power storage unit **10** should have increased close to the lower limit temperature as a result of the process at step S**14**. Therefore, according to the present embodiment, even if it becomes necessary to consume electric power stored in power storage unit **10**, the amount of power consumption is small.

As another possible method of further increasing the temperature of power storage unit **10**, if the state of charge of power storage unit **20** is not full, for example, SOC setting unit **322** may set target values SOC**1**C and SOC**2**C of power storage units **10** and **20** such that power is supplied from power storage unit **10** to power storage unit **20**. According to this method, though electric power is consumed by converters **18** and **28**, the power consumption can be made smaller than in the above-described method.

When the process of step S**17** ends, the temperature increase control process ends. Further if power storage unit temperatures Tb**1** and Tb**2** are both not lower than the corresponding lower limit temperatures at step S**16** (NO at step S**16**), the temperature increase control process ends. After the end of temperature increase control process, various processes, including start of vehicle operation, are executed.

The embodiment of the present invention will be generally summarized again. Power supply device **100** mounted on a vehicle includes power storage unit **10** that is capable of being charged and control unit **30** that controls charging of power supply unit **10**. Control unit **30** includes: SOC setting unit **322**, which sets, at the start of charging power storage unit **10**, the target value of state of charge (SOC) of power storage unit **10** to SOC**1**A (first value) based on the condition of power storage unit **10** and when it receives temperature increase instruction WCM**1** after the start of charging, sets the target value to predetermined SOC**1**B (second value) higher than

SOC1A and converter ECU **34**, which executes the charging process so that the state of charge of power storage unit **10** attains to the target value.

As described above, power storage unit **10** is charged to some extent and temperature increase control is performed in accordance with the temperature increase instruction WCM**1**, so that it becomes possible to perform temperature increase control immediately before the use by the user. As a result, energy necessary for increasing the temperature of power storage unit **10** can be reduced, and hence, temperature of power storage unit **10** can more reliably be increased while preventing decrease of energy efficiency.

It is noted that temperature increase instruction generation unit **320** corresponds to "change instruction generation unit" of the present invention, and temperature increase instruction WCM**1** corresponds to the "change instruction" of the present invention.

Preferably, the information representing the state of power storage unit **10** is the information of temperature around power storage unit **10** (power storage unit temperature Tb**1**). Control unit **30** further includes remaining SOC calculating unit **321** calculating amount of change (remaining SOC) X**1** of power storage unit **10** necessary for increasing temperature of power storage unit **10**. SOC setting unit **322** stores SOC1B in advance, and subtracts X**1** from SOC1B to calculate SOC1A.

More preferably, control unit **30** further includes temperature increase instruction generation unit **320** that generates temperature increase instruction WCM**1**. Temperature increase instruction generation unit **320** determines a start time of starting change of state of charge of power storage unit **10**, based on designated charge end time (set time ST) and amount of change X**1**. When the current time reaches the start time, temperature increase instruction generation unit **320** generates the temperature increase instruction WCM**1**.

More preferably, control unit **30** further includes temperature increase instruction generation unit **320** generating temperature increase instruction WCM**1** in response to a temperature increase request from outside.

More preferably, temperature increase instruction generation unit **320** outputs temperature increase instruction WCM**1** when it receives temperature increase request DMN from modem **202** provided in house **200**. Modem **202** transmits temperature increase request signal DMN in response to a detection result of sensor **206** detecting the user going out from house **200**.

More preferably, temperature increase instruction generation unit **320** outputs temperature increase instruction WCM**1** in response to a remote operation by the user (operation of remote controller **360**, portable telephone **380** or the like).

It becomes possible to change remaining SOC (amount of change X**1**) in accordance with the power storage unit temperature Tb**1** or charge end time (or running start time) and, therefore, power storage unit **10** can be fully charged and the temperature of power storage unit can be increased within a short period of time from when SOC setting unit **322** received temperature increase instruction WCM**1**. Therefore, temperature of power storage unit **10** can more reliably be increased while preventing decrease of energy efficiency.

According to the present embodiment, the vehicle includes any of the above-described power supply devices. This ensures charge/discharge performance of power storage unit and, therefore, running performance of the vehicle can be improved.

In the description above, power storage unit **10** may be replaced by power storage unit **20**, temperature increase instruction WCM**1** by temperature increase instruction WCM**2**, SOC1A and SOC1B by SOC**2**A and SOC**2**B, power storage unit temperature Tb**1** by power storage unit temperature Tb**2**, and amount of change X**1** by amount of change X**2**. In that case, effects similar to those described above can be attained for power storage unit **20**.

Further, power supply device **100** shown in FIG. **1** may be configured to include either one of power storage units **10** and **20** and a converter corresponding to the power storage unit.

Though temperature increase instruction generation unit **320** sets the temperature increase start time based on the input set time ST in the present embodiment, temperature increase instruction generation unit **320** may be configures to allow cancellation of the setting in accordance with a user instruction.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the scope of the present invention being interpreted by the terms of the appended claims.

The invention claimed is:

1. A power supply device mounted on a vehicle, comprising:

a power storage unit capable of being charged; and

a control unit controlling charging of said power storage unit,

said control unit including

a change instruction generation unit generating a change instruction instructing change of state of charge of said power storage unit, based on information representing possibility of use of said vehicle by a user,

a target value setting unit setting, when charging of said power storage unit starts, a target value of state of charge of said power storage unit to a first value based on the condition of said power storage unit, and setting, when said change instruction is received after the start of charging of said power storage unit, said target value to a second value higher than said first value, and

a charge processing unit executing a charging operation based on said target value, wherein

information representing the condition of said power storage unit is information of temperature around said power storage unit;

said control unit further includes

an amount of change calculating unit calculating an amount of change in state of charge of said power storage unit necessary to increase temperature of said power storage unit; and

said target value setting unit stores said second value in advance, and calculates said first value by subtracting said amount of change from said second value.

2. The power supply device according to claim **1**, wherein

said change instruction generation unit determines a start time of starting change of the state of charge of said power storage unit based on a designated charge end time and said amount of change, and when current time reaches said start time, generates said change instruction.

3. The power supply device according to claim **1**, wherein

said change instruction generation unit generates said change instruction in response to a temperature increase request input from outside.

4. The power supply device according to claim **3**, wherein

said change instruction generation unit outputs said change instruction when it receives said temperature increase request from a transmission device provided in a house; and

said transmission device transmits said temperature increase request in response to a result of detection by a sensor detecting a user going out from said house.

5. The power supply device according to claim **3**, wherein

said change instruction generation unit outputs said change instruction in response to a remote operation by a user.

6. A vehicle, comprising:

a power supply device,

said power supply device including

a power storage unit capable of being charged, and

a control unit controlling charging of said power storage unit; and

said control unit having

a change instruction generation unit generating a change instruction instructing change of state of charge of said power storage unit, based on information representing possibility of use of said vehicle by a user,

a target value setting unit setting, when charging of said power storage unit starts, a target value of state of charge of said power storage unit to a first value based on the condition of said power storage unit, and setting, when said change instruction is received after the start of charging of said power storage unit, said target value to a second value higher than said first value, and

a charge processing unit executing a charging operation based on said target value, wherein

information representing the condition of said power storage unit is information of temperature around said power storage unit;

said control unit further includes

an amount of change calculating unit calculating an amount of change in state of charge of said power storage unit necessary to increase temperature of said power storage unit; and

said target value setting unit stores said second value in advance, and calculates said first value by subtracting said amount of change from said second value.

7. The vehicle according to claim **6**, wherein

said change instruction generation unit determines a start time of starting change of the state of charge of said power storage unit based on a designated charge end time and said amount of change, and when current time reaches said start time, generates said change instruction.

8. The vehicle according to claim **6**, wherein

said change instruction generation unit generates said change instruction in response to a temperature increase request input from outside.

9. The vehicle according to claim **8**, wherein

said change instruction generation unit outputs said change instruction when it receives said temperature increase request from a transmission device provided in a house; and

said transmission device transmits said temperature increase request in response to a result of detection by a sensor detecting a user going out from said house.

10. The vehicle according to claim **8**, wherein

said change instruction generation unit outputs said change instruction in response to a remote operation by a user.

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